**­­­Work Paper SCGWP100310A**

**Revision 10**

**Southern California Gas Company**

**Customer Programs Department**

**Deemed Program for Commercial Steam Traps**

**At-a-Glance Summary**

|  |  |
| --- | --- |
| **Measure Codes** | ***SCG:*** SCGWP100310A-Rev10-Msr001 |
| **Measure Description** | Steam Trap Replacement – Commercial 12-24 hr/day |
| **Base Case Description** | N/A |
| **Units** | Per Replacement |
| **Energy Savings** | Values per replacement:   * 119 therms / replacement   Refer to **Section 2** |
| **Full Measure Cost ($/unit)** | $223/ unit |
| **Incremental Measure Cost ($/unit)** | $223/ unit |
| **Effective Useful Life** | 3 yrs. – Source: DEER 2017 NonRes-RCx-Operational |
| **Measure Installation Type** | BRO-Operational (BRO-Op) |
| **Net-to-Gross Ratio** | * 1. – Source: DEER 2014 NonRes-sAll-mStmTrp-dn |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision No. | Date | **Description** | **Author** |
| --- | Dec. 26, 2005 | Original release | EEA (S. Knoke) |
| A | Jan. 20, 2006 | 1. Minor changes | EEA (S. Knoke) |
| B | Jul. 6, 2006 | 1. Added Review and Acceptance page 2. Added Revision History page 3. Added Disclaimer page 4. Added discussion addressing reluctance to adopt technology in Executive Summary 5. Added discussion addressing reluctance to adopt technology in Incentive and Payback chapter | EEA (S. Knoke) |
| C | Nov. 22, 2006 | 1. Added dry cleaners as a new category 2. Measure life reduced to 6 years 3. Added steam loop drawing for dry cleaners 4. Added a discussion of how steam traps work 5. Added a discussion of steam trap failure modes | EEA (S. Knoke) |
| D | Nov. 28, 2006 | 1. Implemented reviewer comments 2. Added more commercial cost data 3. Broadened dry cleaner category to include small commercial | EEA (S. Knoke) |
| E | Dec. 12, 2006 | 1. Implemented review comments 2. Added attachment on steam tips 3. Made steam flow equations consistent 4. Added kW Engineering survey as attachment | EEA (S. Knoke) |
| F | Jan. 26, 2007 | 1. Added Appendix B – Applications 2. Added three incentive levels | EEA (S. Knoke) |
| G |  | 1. Removed Appendix B – Applications 2. Added “Other Commercial and Industrial Category” to include “Industrial <15 psig” and “Commercial 12-24 hr/day” | EEA (S. Knoke) |
| 8 | March 12, 2010 | 1. Changed revision numbering convention to match new template scheme 2. Referenced Steam Trap Workpaper Rev G as Reference 3. Eliminated Commercial <12 hr/day (Dry Cleaners) measure 4. More clearly defined Other Commercial and Other Industrial measures 5. Incorporated adjustment factors to gross energy savings 6. Updated NTG to reflect 2010 -2012 program cycle mandated ratios | Eric Kirchhoff, PE (SCG) |
| 9 | August 12, 2011 | 1. Eliminated industrial categories 2. Revised gross energy savings by including the pressure drop across the control valve per CPUC decision. | ICF (S. Knoke)  Chan Paek |
| 10 | November 12, 2018 | 1. Updated EUL to 3 years per CPUC resolution E-4952 2. Change NTG ratio to NonRes-sAll-mStmTrp-dn (0.68) from default value for new measures 3. Change MAT from Retrofit (RET) to BRO-Operational (BRO-Op) 4. Add summary table | Andres Marquez (SCG) |

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1. General Measure & Baseline Data
   1. Measure & Delivery Description

### Measure Description

This workpaper describes a steam trap replacement measure based on the commercial 12-24 hours per day market segment and steam trap operating pressure.

### Market Segment Description

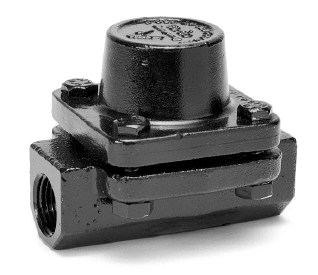
The “Commercial 12-24 hr/day” segment consists of large commercial facilities with a steam plant operating a steam boiler for 12 to 24 hours per day. Such facilities may include large educational facilities, correctional facilities, general medical hospitals, surgical hospitals, agricultural facilities, industrial launderers, tele production and other postproduction services, and transportation equipment suppliers. Small commercial facilities which operate their steam systems less than 12 hours per day are excluded.

### Measure Delivery Description

The steam trap measure is a BRO-Operational (BRO-Op) measure implemented as part of the Investor Owned Utility’s (IOU’s) customer rebate program through which a customer is incented to discover and replace a failed steam trap with a new steam trap.

Faulty steam traps (blocked, leaking, or blow-through) can be diagnosed with ultrasonic, temperature, or conductivity monitoring techniques. Use of such techniques is encouraged to identify steam traps that are eligible to complete the measure requirements for participation in the IOU program.

A new steam trap includes any type of steam trap (thermostatic, mechanical, thermodynamic, or fixed orifice). This may include an entire steam trap or just the replacement of a steam trap “capsule” (the inner part of a steam trap that is specifically designed to be replaced upon failure). The latter does not include existing standard steam traps that are modified, repaired, or are refurbished. See Figures 1 and 2 for more information regarding steam trap capsules.



“Armstrong” CD-60 Series Controlled Disc Trap that contains a replaceable capsule (not shown) accessible by removing bolts located at the top of the housing.

1. Assembled Disc Steam Trap with Replaceable Capsule



1. “Tunstall” Replacement Capsule

### Terms and Conditions

This measure shall be limited only to the replacement of steam traps that have failed (in either the leaking failure, the blow-through failure mode, or failed closed) and are replaced with a new properly functioning steam trap or steam trap capsule. Steam traps designed for any pipe sizes are eligible to participate. New construction is not eligible. The customer may be required to provide the location of the new steam trap in the steam loop, make and model number, a specification sheet, approximate (±5 psig) steam line (not boiler) pressure, and receipts showing the cost and purchase date.

* 1. DEER Differences Analysis

There are no steam trap measures available in DEER.

* 1. Code Analysis

There is no code or other jurisdictional requirements related to these measures.

* 1. Installation Types and Delivery Mechanisms

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| BRO-Operational (BRO-Op) | Above Customer Existing | N/A | EUL | N/A |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Down-Stream Incentive (DnDeemed) | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |

* 1. Measure Effective Useful Life

A measure effective useful life (EUL) of 3 years is adopted as outlined in Table 8 of Public Utilities Commission of the State of California Resolution E-4952.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| NonRes-RCx-Operational | Retrocommissioning and operational programs in non residential settings | Com | ProcHeat | 3 | 1 |

* 1. Net-to-Gross Ratio

The NTG values were obtained using the DEER READI tool. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| NonRes-sAll-mStmTrp-dn | Steam Traps - small commercial non-HVAC application | Com | Any | Any | 0.68 |

* 1. Gross Realization Rate

Not applicable.

* 1. Time-of-Use Adjustment Factor

Not applicable.

1. Energy Savings & Demand Reduction Calculations

Since the publication of the Steam Trap Revision G workpaper [A], recognition of the need for adjustment factors has been realized. These adjustment factors account for:

1. **Pressure factor** -- The recognition that the inlet pressure of a steam trap is greatly reduced due to the effect of a control valve which is between the steam line pressure and the steam trap.
2. **Load factor** -- The recognition that the hours that the trap is leaking steam are often less than the steam system operating hours.
3. **Failed Adjustment Factor** -- Steam traps that were replaced within this program but were mistakenly identified as meeting the failure eligibility requirements, i.e., instead of being failing open (leaking or blowing through), the trap was failed closed (blocked).
   1. Pressure Factor

There are two service categories for steam traps:

* Traps on steam lines (implying the steam trap has the steam line pressure at its inlet, e.g., drip traps)
* Traps on steam loads (implying the steam line pressure has been reduced by a control valve, e.g., tracer, heat exchanger, coil, and process heater traps)

The following engineering assumptions are made to determine the steam trap inlet pressure:

* The inlet pressure of a line trap is the same as the steam line pressure. This analysis assumes that 25% of steam traps are line traps, as recommended by the Energy Division [C].
* The inlet pressure of a load trap is greatly reduced due to the effect of the control valve which is between the steam line and the coil heat exchanger unit. This analysis assumes that 75% of steam traps are load traps, as recommended by the Energy Division [C]. The absolute pressure downstream of the control valve is assumed to be 56% of the trap inlet absolute pressure, as recommended by the Energy Division [C]. Table 1 provides the pressure factors for the two steam trap service categories. We note that this assumption of 56% pressure factor across control valves is conservative. In contrast, Spirax-Sarco recommends assuming a value of 75% [D, p. 25]:

“Where it is not known, it is reasonable to take a pressure drop across the [control] valve of some 25% of the absolute inlet pressure. Lower pressure drops down to 10% can give acceptable results where thermo-hydraulic control systems are used. Greater pressure drops can be used when it is known that the resulting downstream pressure is still sufficiently high. However, steam control valves cannot be selected with output pressures less than 58% of the absolute inlet pressure.”

1. Calculation of Combined Adjustment Factors

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Service** | **Population (%)** | **Load Factor (%)** | **Pressure Factor (%)** | **Combined Factor (%)** |
| Line | 25% | 32% | 100% | 8.0% |
| Load | 75% | 32% | 56% | 13.4% |
| Combined Adjustment Factor (CAF) for Line and Load Traps | | | | 21.4% |

* 1. Load Factor

It has been observed during the previous program cycle that major factors that impact the savings potential of the steam trap measure include the hours the steam leaks (which may not be the same as the boiler hours of operation) or the leak rate of the steam. As illustrated in Figure 3, a steam trap is located downstream of the heat exchanger which is also downstream of its control valve. In practice, the control valve will modulate the flow of steam to the heat exchanger based on the demand requirements. If the control valve and heat exchanger system are working properly, the steam will be fully condensed when it reaches a steam trap operating normally. If the steam trap has failed open, the control valve will supply additional steam to the heat exchanger to maintain the desired pressure or temperature in the heat exchanger. As demand changes, the steam flow will vary through the heat exchanger. The failed trap can only leak steam that is delivered to it. Therefore, a factor can be applied to reduce the steam loss based on the load factor of the heat exchanger. A load factor is simply the effective full load hours (EFLH) divided by the heat exchanger’s operating hours. Process heaters, tank coils, and other steam heat exchangers are analogous to gas-fired process steam boilers, which have a load factor of 32%, as determined for the process boiler workpaper [E]. The process steam boiler load factor intrinsically represents the average load experienced by the boiler. However, if a steam heat exchanger has a 32% load factor, it might operate at 32% load for 100% of its operating hours, or it might operate at 100% load for 32% of its operating hours. If it operates at 32% load for 100% of its operating hours, the average steam loss will be 100% of the maximum steam loss through the trap. If it operates at 100% load for 32% of its operating hours, the average steam loss will be only 32% of the maximum steam loss through the trap. The typical average steam loss will be between these two extremes. For lack of data, it is assumed that the load factor for a leaking steam trap downstream of a control valve is 32%.

Table 1 provides the load factors for the two steam trap service categories, and shows the combined adjustment factor due to the load factor and the pressure factor. This combined adjustment factor (CAF) of 21.4% replaces the “0.67 multiplier” recommended by the Energy Division [C], but will have same effect.



1. Simple Process Flow Diagram of a Steam to Fluid Heat Exchanger
   1. Failed Adjustment Factor

Steam traps that were replaced within this program but were mistakenly identified as meeting the failure eligibility requirements, i.e., instead of being failing open (leaking or blowing through), the trap was failed closed (blocked). A survey of 2,650 steam traps at a large Southern California oil refinery found 27.7% were “leaking heavily” or blow-through, with an additional 6.3% blocked, as discussed in the Steam Trap Revision G workpaper [A]. Thus, the survey showed that 81% [ = 27.7% / ( 27.7% + 6.3% ) ] of the failed traps had failed open. A second adjustment factor called the Failed Adjustment Factor (FAF) of 81% shall be applied to the steam loss per failed trap.

* 1. Energy Savings per Failed Steam Trap

To determine the energy savings per failed steam trap, the energy savings for the measure in this workpaper is post-multiplied by the two adjustment factors just described (CAF and FAF). This simple equation can be expressed as follows:

Eqn. 1

Where

 = Energy savings per failed steam trap (therms/year per trap, gross)

= Energy savings for commercial 12-24 hr/day applications as expressed in the Steam Trap Revision G workpaper [A] -- 687 therms/year per trap, gross

CAF = Combined Adjustment Factor

FAF = Failed Adjustment Factor

1. Energy Savings per Trap

|  |  |
| --- | --- |
| **Measure Description** | **Gross per Trap Savings (th/yr)** |
| Steam Trap Replacement – Large Commercial 12-24 hr/day [A] | 687 |
| Combined Adjustment Factor (CAF) | 21.4% |
| Failed Adjustment Factor (FAF) | 81% |
| Steam Trap Replacement – Large Commercial 12-24 hr/day | 119 |

1. Load Shapes

Not applicable.

1. Base Case & Measure Costs
   1. Base Case Cost

The base case scenario for this measure is to do nothing; therefore the base case cost for this measure is $0.

* 1. Gross Measure Cost

The Gross Measure costs are described in detail in the attached Steam Trap Revision G workpaper [A]. The costs are as follows:

1. Gross Measure Costs per Trap

|  |  |
| --- | --- |
| **Measure Description** | **Gross per Trap Costs ($)** |
| Steam Trap Replacement – Large Commercial 12-24 hr/day | 223 |

* 1. Incremental Measure Cost

The Incremental Measure Costs for these measures are as indicated under Gross Measures Costs.

Attachments

Attachment A – *Steam Traps Workpaper for PY2006-2008, Revision G*, Energy and Environmental Analysis, Inc., March 14, 2007.

References

1. *Steam Traps Workpaper for PY2006-2008, Revision G*, Energy and Environmental Analysis, Inc., March 14, 2007.
2. *Updated DEER NTGR Values*, California Energy Commission, Sacramento, CA, (filename is “Updated DEER NTGR Values (053008).xls”), <http://www.deeresources.com/>.
3. CPUC Energy Division, Data Management and Quality Control reviewers’ recommendation in Steam Trap Workpaper Review Comments (filename SCGWP100310A+SDGENRPR009 – Steam Traps - comments.doc), March 10, 2010.
4. *Design of Fluid Systems--Hook-ups*, Spirax-Sarco, 12th Edition, 2004, p. 25 (Accessed June 23, 2011 at <http://www.spiraxsarco.com/us/pdfs/training/hookup.pdf>).
5. WPSCGNRPH120206A, Process Boilers (Including Direct Contact Water Heaters), Version B, March 20, 2006 (current version is Revision 5, May 28, 2014).